CASE STUDY:

CITY OF PALO ALTO

Population:	**57,000**
1990/91 General Fund *Revenues:* *Fund Balance:*	 **$48 million** **$14 million**
# URMs:	**46**
Type of URMs:	**100% commercial**
Ordinance Type:	**mandatory engineering reports**
Retrofit Incentives:	**(1) reports available to tenants and public** **(2) exemption from zoning requirements**
Funding Source:	**not applicable**

BACKGROUND

The City of Palo Alto, located 30 miles south of San Francisco in Santa Clara County, extends from San Francisco Bay to the lower foothills of the Santa Cruz mountain range. The city is the home of Stanford University. Santa Clara County's "Silicon Valley," renowned for its high technology industry, has its roots in Palo Alto which includes the Hewlett-Packard Corporation among its corporate residents. First incorporated in the mid 1800s, Palo Alto grew by adding discrete sites so that today it includes 43 individual named neighborhoods. Most of the city's retail businesses are concentrated in 5 major commercial zones, 1 of which is a large shopping center and another the traditional downtown.

HAZARDOUS BUILDINGS PROFILE

The city identified 91 buildings as potentially hazardous. Of the potentially hazardous buildings identified, 46 are unreinforced masonry buildings (URMs) located in Palo Alto's downtown area. The buildings are primarily commercial in use, and include, for example, office buildings, a theater, a restaurant, and a supermarket.

ORDINANCE

Palo Alto's ordinance emphasizes identification rather than mitigation, establishing the city's "Seismic Hazards Identification Program." Three categories of buildings are covered by the ordinance:

(1) Buildings constructed of unreinforced masonry (except for those smaller than 1900 square feet with 6 or fewer occupants),
(2) Buildings constructed prior to January 1, 1935 containing 100 or more occupants, and
(3) Buildings constructed prior to August 1, 1976 containing 300 or more occupants.

Exceptions are made for those buildings which have been structurally upgraded in accordance either with the Los Angeles Division 88 Standard for URM buildings or the 1973, or later, edition of the Uniform Building Code.

Owners of buildings in the listed categories are required to submit to the Building Inspection Division of the city detailed engineering reports describing the potential for damage to their structure in the event of an earthquake. The reports are to be prepared by professional structural or civil engineers hired by the building owner.

The city's Building Inspection Division is instructed to notify owners of their responsibilities under the ordinance. The owners are to be notified within 6 months of enactment of the ordinance; however, owners of historic buildings are to receive notice following an 18 month delay to allow them more time to prepare. Engineering reports for URM's (category 1) are due 1 1/2 years from mailed notice, pre-1935 buildings (category 2) are due within 2 years, and pre-1976 buildings (category 3) are due within 2 1/2 years of mailed notice. Within 1 year of submitting the report the owner also must submit to the Building Inspection Division a letter of intent describing plans for taking care of any deficiency.

Upon receipt of an owner's report the Building Inspection Division, with the aid of civil or structural engineers, reviews the report to ensure it conforms with the ordinance's requirements. The report is then made available to all interested individuals. The owner is responsible for notifying tenants, in writing, within 30 days of its submission, that the report is complete and on file with the city. A semiannual status report is to be prepared by the chief building official for distribution to the City Council, discussing the number of buildings analyzed, the severity of structural inadequacies discovered, and any corrective actions undertaken by owners.

Building owners who violate the ordinance are guilty of a misdemeanor punishable by a fine of $500, or by imprisonment in the County jail for a term not to exceed 6 months, or both, for each day they are out of compliance.

INCENTIVE PROGRAM CONCEPT

Palo Alto's approach includes both incentive and pressure to retrofit. Shortly after adopting its retrofit ordinance, the city enacted zoning changes designed to provide incentives for owners of hazardous buildings who are considering retrofitting. The zoning incentives provide that an owner who strengthens a building may add 2,500 square feet or 25% of the existing usable floor area, whichever is greater, up to a maximum zoning floor area ratio of 3:1, and remain exempt from on-site parking requirements.

The "stick" embedded in Palo Alto's program is its requirement that the engineering reports submitted by building owners be made a matter of public record. Palo Alto's residents are generally highly educated and very likely to take an interest in, and do something with, such information. The city also believes that publicizing a building's seismic deficiencies could affect its resale and rental values, its eligibility for refinancing, and the cost of purchasing earthquake insurance. The city felt these financial considerations would lead at least some building owners to retrofit voluntarily.

PROGRAM RESOURCE REQUIREMENTS

The Chief Building Official of the city of Palo Alto, was the individual who spent the most time on developing the city's ordinance, which took 4 years. He was supported in this effort by a civil engineering consultant and a 12 member citizen advisory committee. Outside of staff time and related expenses, there were no costs associated with development of the program. Ongoing resource requirements also are minimal: the city's building official must receive and review the engineers reports prepared by the owners, and report to the city council semi-annually on the number of buildings analyzed. The Building Inspection Division is instructed to hire civil or structural engineers to help with report reviews. The cost of the review is recovered from fees assessed upon the owners based on the time required for the review. Ultimately the city will bear all or a portion of the review costs, as the amount collected from owners will be deducted from the plan checking fee for construction work which deals directly with correcting deficiencies identified in the reports.

PROGRAM DEVELOPMENT

The process of drafting Palo Alto's ordinance began in December 1981. The intention at the time was to pass an ordinance making retrofitting mandatory. The city recognized that a mandatory ordinance could have a negative financial impact on owners but decided against providing any financial assistance. When the first ordinance, which mandated retrofitting, was presented by staff to the city council, the outcry from the business community and the general public led the council to vote against the measure in April 1982.

The city was criticized for not including affected members of the community in the discussion and development of the ordinance. Accordingly, the council directed staff to "establish a citizen's committee to recommend an economical, practical and cost-effective method of reducing seismic hazards in Palo Alto". At least 2 structural engineers and an architect had to be included on the committee. The citizen's committee included representatives of the Chamber of Commerce, the Board of Realtors, the Downtown Merchants Association, Downtown Palo Alto Inc., the California Avenue Area District Association, the Planning Commission, Architectural Review Board and Historic Resources Board. This committee was able to represent the concerns of all the groups affected by the proposed ordinance and provided a vehicle for compromise before the issue would return to the council for a vote.

The citizen's committee and city staff switched their emphasis to development of a voluntary retrofit ordinance, despite the strong opposition of the city's building inspector. Negotiations then began covering, for example, such issues as building classification: although a system identifying 6 different types of hazardous buildings was originally proposed, in the end the committee agreed to divided affected buildings into 3 classes. After 2 years the city's staff and the citizens' committee were able to reach a compromise plan for a voluntary ordinance. In June of 1984 the city council unanimously approved the plan and instructed staff to begin work on an ordinance. The ordinance was adopted by council vote in January, 1986.

PROGRAM EFFECTIVENESS

The results to date of Palo Alto's program are illustrated in the table below. Four projects have requested the zoning waiver, one of which is under construction and another in the building permit process. Nearly half of the buildings for which engineering reports have been submitted have been retrofitted even though that is not mandatory. In addition nearly as many buildings not covered by the ordinance have been retrofitted.

	Category 1	Category 2	Category 3	All Buildings
Total Building	46	18	27	91
Reports Accepted	34	9	12	43 (48%)
Buildings Strengthened, Repaired or Demolished	10	3	7	22 (23%)
Reports Overdue	2	6	8	26* (29%)

* Owners of 11 of the 26 buildings have notified the city that they are in the process of complying

PROGRAM STRENGTHS

Palo Alto's approach promotes retrofitting while requiring virtually no incremental staff time or expenditure. From the owners perspective, the fact that there is no deadline for retrofitting means that they can pursue such projects when it is most convenient, when for example leases expire, building uses change or ownership is transferred.

KEYS TO SUCCESS

As Palo Alto learned from its experience, involvement of the community in drafting the ordinance was critical to its passage. Palo Alto also relies upon the vigilance of its citizens to encourage building owners to correct deficiencies. Without an active community, making the engineering reports generally available would not inspire retrofitting. It is also helpful that Palo Alto is a relatively wealthy community with a thriving downtown, so that given enough time and flexibility owners of hazardous structures generally can find financing for the necessary construction.

Many people believe the zoning incentives offered by Palo Alto had much to do with the program's success but it appears that, after an initial flurry of interest, the expansion incentive has not been widely used.

EXHIBITS

- City of Palo Alto Ordinance #3666

CONTACTS

Fred Herman	Chief Building Official	(415) 329-2550

REFER TO

Earthquake Hazard Identification and Voluntary Mitigation: Palo Alto's City Ordinance, by Fred Herman, James Russell, Stanley Scott and Roland Sharpe, December 1990, SSC 90-05. Published by the Seismic Safety Commission of the State of California; see CONTACTS)

CITY OF PALO ALTO

EXHIBITS

ORDINANCE NO. 3666
ORDINANCE OF THE COUNCIL OF THE CITY OF PALO ALTO ADDING CHAPTER 16.42 TO THE PALO ALTO MUNICIPAL CODE SETTING FORTH A SEISMIC HAZARDS IDENTIFICATION PROGRAM

WHEREAS, the Palo Alto Comprehensive Plan has a Seismic Safety Element which calls for the City to implement measures to lessen risk to human life and property in the event of an earthquake (Environmental Resources Policy 14, Program 47); and

WHEREAS, the City Council established a Seismic Hazard Committee made up of engineers, architects and property owners to thoroughly explore possible seismic hazard programs; and

WHEREAS, the City Council has concluded that it wishes to implement a seismic hazards identification program to require certain building owners to investigate the potential hazards of their buildings; and

WHEREAS, such a seismic hazards identification program is consistent with California Health and Safety Code sections 19160-19169.

NOW, THEREFORE, the Council of the City of Palo Alto does ORDAIN as follows:

SECTION 1. Chapter 16.42 is hereby added to the Palo Alto Municipal Code to read:

Chapter 16.42

SEISMIC HAZARDS IDENTIFICATION PROGRAM

Sections:

16.42.010 Purpose.
16.42.020 Definitions.
16.42.030 Scope of program.
16.42.040 Building categories and implementation schedule.
16.42.050 Engineering reports.
16.42.060 Review of reports.
16.42.070 Responsibilities of the building owners.
16.42.080 Program status reports to the City Council.
16.42.090 Remedies.

16.42.010 Purpose. It is found and declared that in the event of a strong or moderate local earthquake, loss of life or serious injury may result from damage to or collapse of buildings in Palo Alto. It is generally acknowledged that Palo Alto will experience earthquakes in the future due to its proximity to both the San Andreas and Hayward faults. The purpose of this ordinance is to promote public safety by identifying those buildings in Palo Alto which exhibit structural deficiencies and by accurately determining the severity and extent of those deficiencies in relation to their potential for causing loss of life or injury. The City Council finds it desirable to identify the hazards that these deficiencies may pose to occupants of buildings and pedestrians in the event of an earthquake. Such a seismic hazards identification program is consistent with California Health and Safety Code sections 19160-19169 and is necessary to implement the Palo Alto Comprehensive Plan's Environmental Resources Policy 14, Program 47.

16.42.020 Definitions. (a) "Bearing wall" means any wall supporting a floor or roof where the total superimposed load exceeds one hundred (100) pounds per linear foot, or any unreinforced masonry wall supporting its own weight when over six (6) feet in height.

(b) "Building," for the purpose of determining occupant load, means any contiguous or interconnected structure; for purposes of engineering evaluation, means the entire structure or a portion thereof which will respond to seismic forces as a unit.

(c) "Capacity for transfer" means the maximum allowable capacity of a structural system or connection to resist in a ductile manner the lateral forces it would encounter due to earthquake forces.

(d) "Civil engineer or structural engineer" means a licensed civil or structural engineer registered by the State of California pursuant to the rules and regulations of Title 16, Chapter 5 of the California Administrative Code.

(e) "External hazard" means an object attached to or forming the exterior facade of a building which may fall onto pedestrians or occupants of adjacent buildings. Examples of this type of hazard include, but are not limited to, the following:

1. Nonstructural exterior wall panels, such as masonry infill or decorative precast concrete.

2. Parapets.

3. Marquees, awnings or other roof-like projections from a building.

4. Masonry or stone wall veneer and wall ornamentation, including cornices or other decorative appendages.

5. Masonry chimneys.

6. Tile roofing.

7. Wall signs and exterior lighting fixtures hung from a building exterior.

8. Fire escapes or balconies.

(f) "Geometry" means a building's shape or configuration, including setbacks of wall/column lines, reentrant corners, discontinuities in vertical and horizontal lateral force diaphragms, open storefront and building stiffness variations due to the distribution of resisting elements or the use of materials of differing properties within the same structural element, or other irregularities in plan or elevation.

(g) "Occupants" means the total occupant load of a building determined by Table 33-A of the 1973 Uniform Building Code <u>or</u> the actual maximum number of occupants in that building <u>if</u> that number is less than seventy-five percent (75%) of the number determined by using Table 33-A. The number of actual occupants may be documented by counting actual seating capacity if permanent seating is provided in the occupancy, or by employee and client counts which can be substantiated as a practical maximum use of the space in the building. The chief building official will establish the procedure for documenting occupant loads.

(h) "Solution" means any justifiable method that will provide for the transfer of lateral forces through a system or connection to a degree which will substantially eliminate a potential collapse failure. A general description of the methods and materials to be used shall be included in sufficient detail to allow for a cost estimate of the solution to be made (i.e., adding shear walls, overlaying horizontal diaphragms, strengthening critical connections, etc.).

(i) "Unreinforced masonry (URM)" building means any building containing walls constructed wholly or partially with any of the following materials:

1. Unreinforced brick masonry.

2. Unreinforced concrete masonry.

3. Hollow clay tile.

4. Adobe or unburned clay masonry.

16.42.030 Scope of program. (a) Applicability. The following buildings in Palo Alto shall be required to have an engineering report submitted to the City's Building Inspection Division, pursuant to section 16.42.050, to determine: (i) the existence, nature and extent of structural deficiencies which could result in collapse or partial collapse of the building; and (ii) the existence, nature and extent of deficiencies in the anchoring of external hazards:

1. Buildings constructed of unreinforced masonry (URM), except those of less than one thousand and nine hundred (1,900) square feet containing six (6) or fewer occupants.

2. Buildings constructed prior to January 1, 1935 containing one hundred (100) or more occupants.

3. Buildings constructed prior to August 1, 1976 containing three hundred (300) or more occupants.

(b) Exemptions. The following buildings need not comply with this ordinance:

1. Buildings which have been structurally upgraded in substantial accordance with either the Los Angeles Division 88 Standard for URM buildings or the 1973, or later, edition of the Uniform Building Code.

2. Buildings whose uses are subject to amortization under this code; provided that, upon the termination of the nonconforming use, such a building shall be required to be rehabilitated to the then current lateral force requirements in the Uniform Building Code prior to occupancy by a conforming use.

16.42.040 Building categories and implementation schedule. (a) Building Categories. The categories of buildings within the scope of this ordinance are set forth in Table A, below.

(b) Owner Notification. The owners of buildings in categories I through III, except those designated as historic buildings, shall be notified within six (6) months of enactment of this ordinance by the Building Inspection Division of the City of Palo Alto that their buildings are required to have an engineering report submitted to the City. Owners of designated historic buildings, as defined in Chapter 16.49, shall be notified within eighteen (18) months of enactment of this ordinance.

(c) Implementation Schedule. The owners of buildings in categories I through III must submit engineering reports within the time frame set out in Table A, below, from the date of mailed notice by the City.

TABLE A

CATEGORY	DESCRIPTION	ENGINEERING REPORT SUBMITTED WITHIN DATE OF MAILED NOTICE (IN YEARS)
I	All URM buildings.	1 1/2
II	All pre-1935 buildings other than URM with 100 occupants or more.	2
III	All buildings with 300 occupants or more constructed between January 1, 1935 and August 1976.	2 1/2

16.42.050 Engineering reports. (a) Preparation of Reports. Building owners shall employ a civil or structural engineer to prepare the investigation and engineering report outlined below.

(b) Purpose. To investigate, in a thorough and unambiguous fashion, a building's structural systems that resist the forces imposed by earthquakes and to determine if any individual portion or combination of these systems is inadequate to prevent a structural failure (collapse or partial collapse).

(c) General. Each building shall be treated as an individual case without prejudice or comparison to similar type or age buildings which may have greater or lesser earthquake resistance. Generalities or stereotypes are to be avoided in the evaluation process by focusing on the specifics of the structural system of the building in question and the local geology of the land on which the building is constructed.

(d) Level of Investigation. Some buildings will require extensive testing and field investigation to uncover potential structural deficiencies, while others will allow the same level of overall evaluation by a less complicated process due to simplicity of design or the availability of original or subsequent alteration design and construction documents.

It is the responsibility of the engineer performing the evaluation to choose the appropriate level of investigation which will produce a report that is complete and can serve as a sound basis for a conclusion on the collapse hazard the building may present.

(e) Format for the Report. The following is a basic outline of the format each engineering report should follow. This outline is not to be construed to be a constraint on the professional preparing the report, but rather to provide a skeleton framework within which individual approaches to assembling the information required by the ordinance may be accomplished. It also will serve as a means for the City to evaluate the completeness of each report.

1. General Information. A description of the building including: (i) the street address; (ii) the type of occupancy use within the building, with separate uses that generate different occupant loads indicated on a plan showing the square footage of each different use; (iii) plans and elevations showing the location, type and extent of lateral force resisting elements in the building (both horizontal and vertical elements); (iv) a description of the construction materials used in the structural elements and information regarding their present condition; (v) the date of original construction, if known, and the date, if known, of any subsequent additions or substantial structural alterations of the building; and (vi) the name and address of the original designer and contractor, if known, and the name and address of the designer and contractor, if known, for any subsequent additions or substantial structural alterations.

2. Investigation and Evaluation of Structural Systems. All items to be investigated and the methods of investigation for each type of building under consideration are contained in Appendices A and B, available from the City's Building Inspection Division.

3. Test Reports. All field and laboratory test results shall be included in the report. Evaluation of the significance of these test results shall be made with regard to each structural system or typical connection being evaluated. This evaluation may be limited to a statement of the adequacy or inadequacy of the system or connection based on the lateral load demand it would be required to resist by calculation. If tests reveal inadequacy, a conceptual solution must be included in the report.

4. Conclusions. Based on the demand/capacity ratio and the specific evaluation items contained in Appendices A or B, a statement shall be provided explaining the overall significance of the deficiencies found to exist in the building's lateral force resisting system regarding potential collapse or partial collapse failure.

5. Recommendations. An appropriate solution, which could be used to strengthen the structure to alleviate any collapse or partial collapse threat, shall be specified.

(f) Exceptions and Alternatives. Exceptions to the specific items required to be included in an engineering report may be granted by the chief building official upon review of a written request from the engineer preparing the report. Such a request shall provide evidence that adequate information concerning the required item(s) can be determined by alternate means or that a conclusion can be made about the item without following the solution called for in the appropriate appendix. The purpose of granting such exceptions shall be to reduce the costs or disruption that would result from taking required actions, when it can be shown that they are unnecessary to provide information available by other equivalent means. In no case will an exception be granted which would result in an item not being completely evaluated. The decision of the chief building official in granting exceptions is final.

16.42.060 Review of reports. (a) The City shall utilize the services of civil or structural engineers to assist the Building Inspection Division in determining if the submitted engineering reports conform to the requirements of this chapter.

(b) The cost of this review shall be recovered by a fee assessed from the building owner based on the time required for the review. This fee amount shall be deducted from the plan checking fee collected for any future construction work that deals directly with correcting any of the structural inadequacies specified in the engineering report.

(c) Copies of the engineering reports shall be available to interested individuals for a standard copying fee or may be reviewed at the Building Inspection Division offices.

16.42.070 Responsibilities of the building owners. (a) Notification of Building Tenants. A building owner shall notify all tenants, in writing, that a structural investigation has been performed and that the report is available at the Building Inspection Division offices. This notice must be sent within thirty (30) days of the date the report is submitted to the City.

(b) Letter of Intent. A building owner shall submit a letter to the Building Inspection Division within one (1) year of the date the engineering report was submitted, indicating the owner's intentions for dealing with the potential collapse hazards found to exist in the building.

16.42.080 Program status reports to the City Council. The chief building official shall submit a semiannual report to the City Council on the status of the seismic hazards identification program. The reports shall include information regarding the number of buildings analyzed, the severity of the structural inadequacies discovered and any actions taken by individual building owners to correct these inadequacies.

16.42.090 Remedies. It shall be unlawful for the owner of a building identified as being included in the scope of this ordinance to fail to submit a report on either building collapse hazards or external hazards within the time period specified in section 16.42.040(c), Table A, or to fail to submit a letter of intent within the time period specified in section 16.42.070(b). The following remedies are available to the City:

(a) The City may seek injunctive relief on behalf of the public to enjoin a building owner's violation of this ordinance.

(b) A building owner violating this ordinance shall be guilty of a misdemeanor and, upon conviction thereof, shall be punishable by a fine of not more than Five Hundred Dollars ($500) or by imprisonment in the Santa Clara County Jail for a term not exceeding six (6) months, or by both such fine and imprisonment. Such building owner is guilty of a separate offense for each and every day during any portion of which such violation of this ordinance is committed, continued or permitted by such building owner.

(c) These remedies are not exclusive.

SECTION 2. The Council hereby finds that this ordinance will have no significant adverse environmental impact.

SECTION 3. This ordinance shall become effective upon the commencement of the thirty-first day after the day of its passage.

INTRODUCED: January 20, 1986

PASSED: February 3, 1986

AYES: Bechtel, Cobb, Fletcher, Klein, Levy, Patitucci, Renzel, Sutorius, Woolley

NOES: None

ABSTENTIONS: None

ABSENT: None

ATTEST:

Gloria L. Young
City Clerk

APPROVED:

Michael Cobb
Mayor

APPROVED AS TO FORM:

Margaret A. Sloan
Sr. Assistant City Attorney

APPROVED:

William Zaner
City Manager

Kenneth R. Schreiber
Director of Planning and Community Environment

Fred Herman
Chief Building Official

APPENDIX A

Procedures for Investigation of All Buildings
(Except Unreinforced Masonry Bearing Wall Types)

(a) Preliminary Field Survey. Provide drawings of the building in plan, elevation and section sufficiently detailed to reveal the correct dimensions of the spans and extent of all structural elements in the building, including openings in walls and changes in framing directions or other data which will be used to evaluate the building.

(b) Areas of Special Investigation.

(1) Specify the type of roof diaphragm used in the building and its capacity for transfer of lateral forces.

(2) If the building is multi-story specify the existing floor diaphragm at each level above the foundation and give its capacity for transfer of lateral forces.

(3) Specify the types and spacing of connections used at each level to transfer the forces of the horizontal diaphragms into the vertical shear resisting elements of the structure, and the capacity for transfer of each type of connection present in the building.

(4) Specify the type of vertical structural elements which resist lateral forces and their individual capacities as determined either by testing or use of standard values for the types of construction found in the vertical elements.

(5) Specify the type and spacing of connections used to connect vertical shear resisting elements to each other and to the building foundation, and the capacity for transfer of each type of connection present.

(6) Specify the type of foundation system used and note any evidence of settlement.

(7) Specify the type of connection used to attach wall appendages or pre-cast wall elements to the structural frame.

Standards for the Analysis and Evaluation of All Buildings
(Except Unreinforced Masonry Bearing Wall Types)

(a) Purpose. The objective of these investigations is to identify and quantify the structural inadequacies that may be present in a building which could lead to a collapse or partial collapse during an earthquake. The focus of the reports should be 1) determining the potential life safety threat that the building presents to its occupants and 2) the potential threat to pedestrians or occupants of adjacent buildings from falling external hazards.

(b) Capacity vs Demand of the Existing Structural System and Its Elements.

(1) Define the overall type of lateral force resisting system used in the building based on Table 23-I of the 1973 Uniform Building Code. If the building has a dual or hybrid system, describe the systems and explain how they function both in combination and separately to justify the "K" factor to be choosen.

(2) For each type of diaphragm, shear wall, moment frame, braced frame and interconnection of lateral force resisting systems provide an analysis of the loads (demand) which these elements would be subject to based on the design parameters set forth in the 1973 edition of the Uniform Building Code.

(3) For each type of diaphragm, shear wall, frame and interconnection of lateral force resisting system determine a maximum capacity based on currently accepted or published allowable values, adjusted as appropriate for the material involved when used to resist earthquake forces.

(4) Provide a ratio of capacity to demand for each system or interconnection evaluated in (2) and (3) above and provide a statement of the significance of this ratio, regarding the potential for failures which could lead to a collapse, considering the materials used and the type of lateral force resisting system present.

(c) Specific Evaluation Items. The report shall contain a statement regarding the significance of each item in this section which is found to occur in the building.

(1) General.

A. Assess the condition of the structure, the quality of workmanship, the level of maintenance and the type of construction with regard to the potential loss of strength in the structural systems due to decay or deterioration.

B. Assess the redundancy exhibited in the structural system and the reserve capacity that elements of the system may provide.

C. Assess the presence or lack of ductility in the lateral force resisting elements and ductility differences due to the use of dissimilar materials in the horizontal and vertical diaphragms.

D. Assess how adequately the building is tied together in an overall sense to allow the lateral force resisting systems an opportunity to receive the forces they are designed to resist.

(2) Geometry.

A. Consider how and where torsional (rotation) forces, induced by the eccentricity of the building center of mass to its center of rigidity, are taken into the lateral force resisting system and identify the individual elements which will transmit these additional forces. Assess the potential capacity these elements have to resist the additional loads from this source.

B. Consider the effects of discontinuities in the lateral force resisting systems with regard to the existence of adequate ties, boundary members, chords or drag struts, etc. to allow redistribution of forces. Assess the capacity of the systems or elements which would receive the redistributed forces if adequate ties exist.

C. Consider the effects of reentrant corners (including the shape of individual columns) and assess their contribution to the response of the building at locations where they occur.

(3) Building Separation.

A. Consider the effects of adjoining buildings, which may have different vibration periods resulting in non-synchronized movement of the adjacent exterior walls, placing out of plane impact forces on these walls.

B. Assess the level of drift control, particularly at open storefronts and the actual physical separation distance between the exterior walls of the building and ajoining building walls.

C. Assess conditions where the wall of a building on one property provides support for structural elements of the adjoining property's building.

(4) Non-Ductile Reinforced Concrete Frames.

A. Consider non-ductile frames which act alone without the benefit of shear walls or braced frames.

B. Assess the level of compression or shear forces due to existing vertical loads on the critical supporting elements of the frame.

C. Assess masonry infill walls between frame members and their effect on the forces a column/beam joint will be subjected to when attempting to transmit lateral forces into these walls.

(5) Precast Concrete Connections

A. Assess the effects of temperature creep and shrinkage of concrete surrounding welded insert connections to precast systems and elements.

B. Consider the potential brittle failure of such connections.

(6) Non-Structural Elements.

A. Assess the effect that partitions, infill walls, precast concrete exterior (architectural) elements and ceiling systems. which have considerable strength and stiffness characteristics, may have on the overall response of the building.

B. Assess the effect of inadvertant bracing by non-structural elements such as infill walls, stair stringers or other situations of localized restraint on columns.

C. Assess the potential stress concentrations at the unrestrained ends of columns which may result from partial restraint or bracing of columns.

(7) Site Geology.

A. Consider the maximum ground shaking intensity for the building site and liquefaction potential or susceptibility by using available earthquake hazard maps.

B. Assess any existing site specific geology/soils reports to gauge the effects that the local conditions may have on the overall response of the building.

APPENDIX B

Procedures for Investigation of Unreinforced Masonry Bearing Wall Buildings

(a) Preliminary Field Survey. Prepare framing plans for roof and floors noting all beams, trusses or major lintels of all URM piers or pilasters. Prepare elevations of all URM walls noting all openings in the walls and any discontinuities above the building base.

(b) Special investigations of the following nature must be made:

(1) Note all parts of the vertical load carrying system that may act as ties to lateral load-resisting elements, to determine the elements or systems that may control relative displacements between the building's base, floors and roof.

(2) Note on floor plans all interior crosswalls that are continuous between floors or floor and roof, even if the connection of such walls to the floor or roof is only by finishes.

(3) Draw the relationship of roof or floor framing and ceiling framing to determine the extent and method if any, of their inter-connection.

(4) Draw the support systems for URM walls that are not continuous to the building base noting the materials used to provide that support. (i.e., steel frame, concrete frame, etc.)

(5) Draw on floor and roof plans the extent of sheathing and finish materials and describe their nature and nailing pattern. Note any difference in materials used which could lead to substantial variations in diaphragm stiffness. Openings in floors or roofs adjacent to URM walls must be noted. Note the type of roofing system currently in place and note if this roofing is applied directly to the main roof deck or if there are locations where it is on a cricket or other superimposed deck.

(c) Investigation of current anchorage of URM walls to floors and roof. Show the location of all wall anchors on the floor/roof plans and specify their spacing, size, and method of connection. Details of the existing anchorage system should be prepared. Embedded portions of anchors must be exposed to determine this level of detail. A minimum of 2 percent or 2 anchors exposed per floor or roof level should establish average conditions.

(d) Investigation of existing URM walls. Investigate the following items if they occur in the building, and determine:

(1) The thickness of URM walls at all levels and location of any changes in thickness.

(2) The materials used for lintels and masonry arches and their bearing area on columns or piers.

(3) The materials used in columns or piers supporting lintel beams or arches.

(4) The height of parapets, cornices, and gable ends of URM walls above the uppermost existing anchorages.

(5) The anchorage or bonding of terra cotta, cast-stone or similar facing to the back up wythes of brickwork at cornices and other architectural appendages.

(6) The coursing of exterior wythes of masonry, the bonding of wythes of masonry, and the materials used in each wythe.

(7) The condition of mortar joints and areas of lightly unburned brick should be noted on the wall elevations. Existing cracks in wall elements should also be noted.

(e) Testing. The testing of existing anchorage systems must be made to determine an average capacity. Testing shall be accomplished in accordance with the following requirements.

(1) Existing Wall Anchors of URM Buildings. Five (5) percent of existing rod anchors shall be tested in pullout by an approved testing laboratory. The minimum tested quantity shall be four (4) per floor or roof level, with two (2) tests at walls with framing perpendicular to the wall and two (2) at walls with framing parallel to the wall.

The test apparatus shall be supported on the masonry wall at a minimum distance of the wall thickness from the anchor tested. Where due to obstructions this is not possible, details of the condition encountered and the alternate method used must be included in the test result report, with calibration adjustment for conditions where the reaction of the test apparatus contributes to the tension value of the anchor.

The rod anchor shall be given a preload of 300 pounds prior to establishing a datum for recording elongation. The tension test load reported shall be recorded at 1/8" relative movement of the anchor to the adjacent masonry wall surface.

The testing of existing URM walls to determine the allowable bed-joint shear is required in accordance with the following requirements.

(2) In Place Shear Tests of Brick Masonry. The bed joints of the outer wythe of the masonry shall be tested in shear by laterally displacing a single brick relative to the adjacent bricks in that wythe. The opposite head joint of the brick to be tested shall be removed and cleaned prior to testing. Steel bearing plates of the full dimension of the brick shall be inserted at

each end of the test jack. The bearing plates shall not contact the mortar joint. The minimum quality mortar in 80 percent of the shear tests shall not be less than the total of 30 psi when reduced to an equivalent zero axial stress. The shear stress shall be based on the gross area of both bed joints and shall be that at which movement of the adjacent brick is first observed.

The minimum quantity of tests shall be two (2) per wall or line of wall elements resisting a common force (i.e., per story) or one (1) per 1500 square feet of total URM wall surface, with a minimum of 8 tests for any building. The tests should be conducted at least two brick courses above or below the bond course and be distributed vertically to include a variety of dead load surcharge situations. The exact test location shall be determined at the building site by the engineer responsible for the investigation and the distribution of such tests must be approved by the building official prior to actual testing. In single story buildings, the wall above the lintel beam at an open storefront need not be tested.

Standards for the Analysis and Evaluation of Unreinforced Masonry Bearing Wall Buildings

(a) Analysis

(1) General

The total lateral seismic forces should be computed in accordance with the following equation:

$$V = ZIKCSW$$

The value of KCS need not exceed the value set forth in Table B1-1. The value of Z and I shall be equal to 1.0. The value of W shall be as set forth in the Uniform Building Code.

(2) Lateral Forces on Elements of Structures.

Parts or portions of buildings and structures shall be analyzed for lateral loads in accordance with Chapter 23 of the UBC but not less than the value from the following equation:

$$F_p = IC_pSW_p$$

For the provisions of this section, the product of IS need not exceed 1.0. The value of C_p and W_p shall be as set forth in the UBC.

Exception: Unreinforced masonry walls may be analyzed in accordance with Section (b).

(3) The elements of buildings required to be analyzed shall include the following:

-3-

Wall height to thickness ratio.
Tension bolts for bending.
In-plane shear forces.
Parapets.
Diaphragm stress and diaphragm chords at floors and roof.

(4) Anchorage and Interconnection.

Anchorage and interconnection of all parts, portions and elements of the structure shall be analyzed for lateral forces in accordance with the UBC and the formula in Subsection (2) above. Masonry walls shall be anchored to all floors or roof to resist a minimum of 200 pounds per linear foot acting normal to the wall at the level of the floor or roof or will be considered inadequate.

(5) Required Analysis.

Except as modified herein, the analysis and recommended structural alteration of the structure shall be in accordance with the analysis specified in the UBC. A complete, continuous load path from every part or portion of the structure to the ground shall be shown to exist for required lateral forces. All parts, portions or elements of the structure shall be shown to be interconnected by positive means.

(6) Analysis Procedure.

Stresses in materials and existing construction utilized to transfer seismic forces from the ground to parts or portions of the structure shall conform to those permitted by the UBC and those types of materials of construction specified under the Materials of Construction Section (b). In addition to the seismic forces required, unreinforced masonry walls shall be analyzed as specified in the UBC to withstand all vertical loads. When calculating shear or diagonal tension stresses due to seismic forces, existing masonry shear walls may be allowed to resist 1.0 times the required forces in lieu of the 1.5 factor required by the UBC. No allowable tension stress will be permitted in unreinforced masonry walls. Walls not capable of resisting the required design forces specified in this appendix shall be deemed inadequate.

Exception: Unreinforced masonry walls which carry no design loads other than their own weight may be considered as veneer if they are adequately anchored to elements which are not part of the existing lateral force resisting system.

(7) Existing materials.

When stress in existing lateral force resisting elements are due to a combination of dead loads plus live loads plus seismic loads, the allowable working stress specified in the UBC may be increased 100 percent. However, no increase will be permitted in the stresses allowed in Section (b). The stresses in members due only to seismic and dead loads shall not exceed the values permitted in the UBC.

(8) Allowable reduction of bending stress by vertical load.

Calculated tensile fiber stress may be reduced by the full direct stress due to vertical dead loads.

(b) Materials of Construction.

(1) General

All materials permitted by this code, including their appropriate allowable stresses and those existing configurations of materials specified herein, may be utilized to show adequacy of existing construction.

(2) Existing Materials.

Unreinforced masonry walls analyzed in accordance with this appendix may provide vertical support for roof and floor construction and resistance to lateral loads. The bonding of such walls shall be as specified in the UBC.

Tension stresses due to seismic forces acting normal to the wall may be neglected if the wall does not exceed the Height to Thickness ratio and the in-plane shear stresses due to seismic loads set forth in Table B1-2. If the Wall Height or Length to Thickness ratio exceeds the specified limits, the wall will be considered inadequate unless braced by vertical members designed to satisfy the requirements of the UBC. The deflection of such bracing members at design loads shall not exceed one-tenth of the wall thickness.

Exception: The wall may be supported by flexible vertical bracing members designed in accordance with this appendix if the deflection at design loads is not less than one quarter nor more than one third of the wall thickness.

All vertical bracing members shall be attached to floor and roof construction for the design loads independently of wall anchors. Horizontal spacing of vertical bracing members shall not exceed one-half the unsupported height of the wall or ten feet, whichever is less.

(3) Existing roof, floors, walls, footings and wood framing.

Existing materials, including wood shear walls may be used as part of the lateral load resisting system, provided that the stresses in these materials do not exceed the values shown in Table B1-3. Wood shear walls may be recommended to strengthen portions of the existing seismic resisting system.

(4) Minimum Acceptable Quality of Existing Unreinforced Masonry Walls.

All unreinforced masonry walls utilized to carry vertical loads and seismic forces parallel and perpendicular to the wall plane shall be tested as specified in Section (e) of the investigation portion of this appendix. All masonry shall be of a quality not less than the minimum standards established or shall be considered inadequate. Pointing of mortar of all masonry wall joints may be performed prior to testing if joints are raked and cleaned to remove loose and deteriorated mortar. Mortar shall be Type S or N, except masonry cements shall not be used. All preparation and pointing shall be done under the continuous inspection of a special inspector, whose reports shall be included in the final report.

(5) Determination of Allowable Stresses for Design Methods Based on Test Results.

Design seismic in-plane shear stresses shall be related to test results in accordance with Table 81-4. Intermediate values between 3 and 10 psi may be interpolated.

Compression stresses for unreinforced masonry having a minimum design shear value of 3 psi shall not exceed 100 psi. Design tension values for unreinforced masonry shall not be permitted.

(6) Construction Details.

All unreinforced masonry walls shall be anchored at all floors and roof with tension bolts through the wall or by existing rod anchors at a maximum spacing of six feet. All existing rod anchors shall be secured to the joists to develop the required forces. Testing of the existing rod anchors shall be conducted according to Section (e) of the investigation portion of this appendix.

Diaphragm chord stresses of horizontal diaphragms shall be developed in existing materials or be considered inadequate.

Where trusses or beams other than rafters and joists are supported on masonry piers, these piers must be shown to provide adequate support during seismic loading.

Parapets and exterior wall appendages not capable of resisting the forces specified in this appendix shall be considered hazardous, and methods for proper anchorage must be developed.

TABLE B1-1
HORIZONTAL FORCE FACTORS BASED
ON OCCUPANT LOAD

OCCUPANT LOAD	KCS
Building with an occupant load greater than 100	0.133
All others	0.100

TABLE B1-2
ALLOWABLE VALUE OF HEIGHT-THICKNESS (h/t) RATIO
OF UNREINFORCED MASONRY WALLS WITH MINIMUM
QUALITY MORTAR

	BUILDINGS WITH COMPLYING CROSSWALLS	ALL OTHER BUILDINGS
Walls of one-story buildings	16	13
First-story wall of multistory buildings	16	15
Walls in top story of multistory buildings	14	9
All other walls	16	13

NOTES:

1. Minimum quality mortar shall be determined by laboratory testing in accordance with Section (e) of the investigation portion of this appendix.

2. The wall height may be measured vertically to bracing elements other than a floor or roof. Spacing of the bracing elements and wall anchors shall not exceed six feet.

3. Crosswalls are defined as interior walls of masonry or wood frame construction with surface finish of wood lath and plaster, 1/2" thick gypsum board, or solid horizontal wood sheathing. They may not exceed 40 feet horizontal separation, must be full story height with a minimum length of 1 1/2 times the story height and be continuous through all stories.

TABLE B1-3
VALUES FOR EXISTING MATERIALS[1]

1. Horizontal Diaphragms	
a. Roofs with straight sheathing with the roof covering applied directly to the sheathing.	100 pounds per foot for seismic shear
b. Roofs with diagonal sheathing with the roof covering applied directly to the sheathing.	400 pounds per foot for seismic shear
c. Floors with straight tongue and groove sheathing.	150 pounds per foot for seismic shear
d. Floors with straight sheathing and finished wood flooring.	300 pounds per foot for seismic shear
e. Floors with diagonal sheathing and finished wood flooring.	450 pounds per foot for seismic shear
f. Floors or roofs with straight sheathing and plaster applied to the values for items 1-a and 1-c joist or rafters.	Add 50 pounds per foot to the allowable
2. Shear Walls	
Wood stud walls with lath and plaster	100 pounds per foot each side for seismic shear
3. Plain Concrete Footings	f'_c = 1500 psi unless otherwise shown by tests
4. Douglas Fir Wood	Allowable stress same as No. 1 D.F.[2]
5. Reinforcing Steel	f'_c = 18,000 psi maximum[2]
6. Structural Steel	f'_c = 20,000 psi maximum[2]

[1] Material must be sound and in good condition.

[2] Stresses given may be increased for combinations of loads as specified in Subsection (b) of the analysis and evaluation portion of this appendix.

TABLE B1-4
ALLOWABLE SHEAR STRESS FOR TESTED
UNREINFORCED MASONRY WALLS

SHEAR TESTS	
Eighty percent of test results in psi not less than:	Seismic in-plane shear in psi based on gross area[1]
30 plus axial stress	3
40 plus axial stress	4
50 plus axial stress	5
100 plus axial stress or more	10 (maximum)

[1] Allowable shear stress may be increased by addition of 10 percent of the axial stress due to the weight of the wall directly above.